Optimum Selection of Contracts In A Supply Chain

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Abstract- *In supply chain management a supply contract specifies parameters governing the buyer-supplier relationship. In addition to making the terms of the buyer-supplier relationship explicit, contracts have significant impact on the behaviour and performance of all stages in a supply chain. A supply chain contract should have the ability to increase the firm's profits and supply chain profits and offer incentives to the supplier to improve performance along key dimensions. This paper analyses the various supply chain contracts that improves the profit of the firm and the supply chain. In this paper the analysis is made on buyback, revenue sharing and quantity flexibility contracts to account the impact of these contracts in the supply chain.*

Keywords- supply chain management, contracts, profit

I. INTRODUCTION

Optimal supply chain performance requires the execution of a precise set of actions. Unfortunately, those actions are not always in the best interest of the members in the supply chain, i.e., the supply chain members are primarily concerned with optimizing their own objectives, and that self serving focus often results in poor performance. However, optimal performance can be achieved if the firms coordinate by contracting on a set of transfer payments such that each firm's objective becomes aligned with the supply chain's objective.

The supply chain management paradigm asserts that when making decisions, the efficiency of the whole system should be taken into consideration. When decision making is decentralized, i.e. decisions are made by independent agents comprising the chain, optimization of system's total efficiency might be discordant with the agents incentives. Therefore, coordinating the agents' decisions becomes a major issue. By viewing a supply chain as nexus-of-contracts by Wang and Parlar (1994), i.e. a group of rational agents interacting with each other according to pre-specified rules, an improved supply chain management is achieved by designing appropriate contracts coordinating the agents' decisions. This is the main objective of research on coordinating contracts. Although contracts have been studied in law, economics, and marketing disciplines, their study in SCM takes a rather different approach.

Supply chain contract analysis distinguishes itself on the focus on operational details, requiring more explicit modeling of materials flows and complicating factors such as uncertainty in the supply or demand of products, forecasting and the possibility of revising those forecasts, constrained production capacity, and penalties for overtime and expediting" viewed Tsay et al., (1999). A contract specifies mechanisms for governing the interaction contingencies among agents. It manifests the exchange of promises regarding the actions which are to be done in time. Necessarily, contracts must be enforceable, i.e. the agent's refrainment from fulfilling their promises should be ruled out (or made highly improbable). For a contract to be enforceable, its terms (the mutual promises), should be verifiable by an enforcing body. However, the verifiability of contract's terms is dependent on the enforcing body. If a contract's terms are verifiable by a court of law, that contract would be a legal contract.

Supply chain contracts are not always required to be legal. Several papers in the literature consider contracts among independent agents that are divisions of the same company and a higher level manager can verify the rendition of lateral promised by Chen (1999); Lee and Whang (1999) and Zhang (2006). Nevertheless, the process of contract design should explicitly point out the verifying ability of the enforcing agent. Two approaches to verification are detectable in the literature: direct, and indirect. In direct verification, the conditions regarding the fulfillment of contract terms must be observed. In indirect verification, the aforementioned conditions may be inferred. In reality, the verification process is a mixture of the two approaches. An example of direct verification is the delivery of the ordered products from a supplier by a retailer. The retailer can observe, i.e. count, the number of products received. Indirect verifications are achieved when a certain action is considered to be necessary (or self-enforcing) for a rational agent. For example, a manufacturer can verify that if the market selling price is greater than the total production cost and salvage value, the retailer would satisfy market demand as much as it can. The study of supply chain contracts is an interdisciplinary research area.

Introduction to Supply Chain Contracts

"Supply Chain Management deals with the management of material, information and financial flows in a network consisting of vendors, manufacturers, distributors, and customers" aver Anupindi and Bassok (1997). Exchange of flows can be regarded as a routine transaction, occurring between any pair of suppliers and buyers in the network. Ideally, the quantity and pricing decisions in the supply chain, as shown in Fig. 1, would be made by a single decision maker who has all information at hand. Researchers in Supply Chain Management generally refer to this situation as the centralized or integrated supply chain and call it as the single decision maker of the integrated firm. Similarly, a supply chain is called decentralized if the network consists of multiple decision makers having different information and incentives. The decentralized supply chain or in other words, is inefficient, since the total expected profit of the decentralized supply chain is smaller than the expected profit of the centralized supply chain. To enable coordination, the supply chain resorts to contracts. In general, the goal is to write contracts that induce coordination through appropriate provisions for information and incentives such that supply chain performance will be optimized. This type of approach recurs in a broad range of settings. Cachon (2003) reviewed the respective research on supply chain contracts.

An important objective of supply chain contracts is system wide performance improvement. Another motive that is pursued by entering into supply chain contracts is sharing the risk arising from the uncertainty in the supply chain, the notion of risk should be handled with care, given that the firms are assumed to be risk neutral. Due to globalization and outsourcing, decentralized supply chains are prevalent today. Outsourcing of production, for example, automatically spreads decision rights among multiple decision makers. Even highly vertically integrated firms decentralize decision rights to set incentives and structure the flow of information.

To measure the performance of supply chains, coordination is an important assessment criterion. The terms network, channel or supply chain coordination all refer to the same situation. Anupindi and Bassok (1997) viewed "A single decision maker optimizes the network with the union of information that the various decision makers have". Decision makers are often reluctant to share private information regarding cost and demand, which may lead to suboptimal supply chain performance stated Corbett and Tang (1999) and Corbett et al., (2004). As each decision maker optimizes a private objective function, the local optima need not be globally optimal for the whole supply chain. This clearly is a case where locally optimal decisions of supplier and buyer do not optimize the global supply chain problem. Even if information received is asymmetry, lack of coordination and lack of suboptimal supply chain performance may still occur. Coordination and supply chain performance is at risk as soon as there are multiple decision makers in the network who may have different private information and incentives.

Early overviews on supply chain coordination with contracts were given by Whang (1995); Cachon (2003); Lariviere (1999) and Tsay et al., (1999). Similar approaches can be found in related fields of research like the Literature of Economics on vertical restraints by Mathewson and Winter (1984); Katz (1989) and the Marketing literature on Channel Coordination by Jeuland and Shugan (1983); Moorthy (1987). Tightly linked are the papers by Bergen et al., (1992) and Van Ackere (1993) who studied on agency relationships.
The problem of double marginalization is a prominent example of this phenomenon, first described by Spengler (1950) in the Literature of Economics. Tirole (1990) remarked that when operating independently, supplier and buyer will produce less than a vertically integrated monopolist, because they receive less than the total contribution margin at any given quantity.

Supply Chain Structure

A one-period supply chain model forms the basis for a wide range of supply chain analyses as described by Tsay et al., (1999).

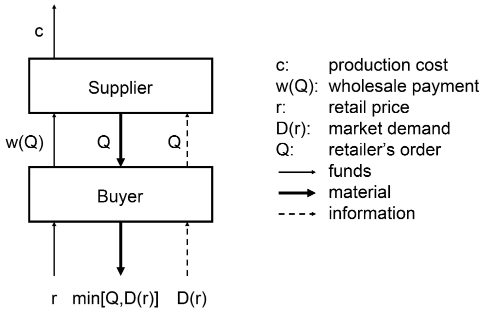


Fig.1

The basic one period supply chain model (adopted from Tsay et al., 1999)

Two consecutive nodes of the supply chain referred here as supplier and buyer, as depicted in Figure 1, together with the material, information and financial flows involved. As shown in Fig. 1, the one-period framework, where the supplier produces or acquires a product at a constant unit cost of c and charges the buyer the wholesale or transfer payment w(Q) per delivery, where w(Q) may either be exogenous or a decision variable of one of the parties. On the other side, the buyer sells the product to the market at retail price r per unit. In reality, market demand D(r) is both price-sensitive and uncertain. Although some models include both features, as it is common to fix either the order quantity or the retail price. In the Operations Research literature, the primary decision variable is the order quantity Q, the retail price is often assumed to be fixed and market demand is stochastic. In the literature of Economics and Marketing, the decision is primarily the retail price r. In the latter case, a common assumption is a deterministic, downward-sloping demand function. Moreover, most papers on supply chain contracts assume only a one-period problem, since the related models are often too complex to be tractable in a multi-period setting.

CONTRACTS FOR SUPPLY CHAIN PROFITS

Actions taken by the two parties in the supply chain often results in profits that are lower than what could be achieved if the supply chain were to coordinate its actions with a common objective of maximizing supply chain profits. In a contract in which the supplier specifies a fixed price and the buyer decides on the quantity to be purchased, the most common cause for suboptimal supply chain performance is double marginalization. The retailer makes its buying decision before demand is realized and thus bears all the demand uncertainty. If demand is less than the retailer’s inventory, the retailer has to liquidate unsold product at a discount. Given uncertain demand, the retailer decides on the purchase quantity based on its margin and the cost of overstocking. The retailer’s margin however, is lower than the contribution margin for the entire supply chain, whereas its cost of overstocking is higher than that of the entire supply chain. As a result, the retailer is conservative and aims for a lower level of product availability than is optimal for the supply chain.

To increase the overall profits, the supplier must design a contract that encourages the buyer to purchase more and increase the level of product availability. This requires the supplier to share in some of the buyer’s uncertainty. Three contracts that increase overall profits by making the supplier share some of the buyer’s demand uncertainty are (i) Buyback or returns contracts; (ii) Revenue sharing contracts; (iii) Quantity Flexibility contracts.

II. OBJECTIVES OF THE STUDY

The Objective of the study **“Analysis of Supply Chain Contracts”** are as follows:

- To study the characteristics of various supply chain contracts
- To analyze the effect of supply chain contract on firm’s profit and total supply chain profits
- To analyze the impact of demand pattern on the performance of the supply chain contracts
- To study the influence of wholesale price on the order quantity under various demand patterns

III. METHODOLOGY

Selection of Contracts

A contract is an agreement between two or more competent persons or companies to perform or not to perform specific acts or services or to deliver merchandise. A contract may be oral or written. A purchase agreement when accepted by a supplier becomes a contract. The products for the contracts may include items such as steel rods, cement, video CDs, music CDs, software, newspapers, magazines, books and products dealing with multiple retailers. Among the various types of contracts available the investigator selected Buyback contract, Quantity flexibility contract and Revenue sharing contract. These contracts are selected particularly because they are capable of improving the supply chain coordination as referred by Cachon and Lariviere (2005).

Demand Pattern for the Study

The demand for a product item is not known and probabilistic distribution is used to calculate the demand. Normal distribution is used in this analysis. The demand pattern normally falls in three categories namely low, normal and high demand pattern. The mean and standard deviation of the weekly demand of the selected product for a period of three months each are calculated for a period of nine months. During the nine months of study, based on the weekly demands, the data collected and analyzed falls in three categories such as low demand pattern in which the mean and standard deviation is 900 and 250 respectively, normal demand pattern in which the mean and standard deviation is 1000 and 300 respectively and as high demand pattern in which the mean and standard deviation is 1500 and 400 respectively. Based on the results obtained the demand pattern for the selected product for the study is undertaken by the investigator as low, normal and high demand patterns.

Low Demand Pattern: From the weekly demand pattern the demand with mean 900 and standard deviation 250 is assumed to be normally distributed and is taken as low demand pattern for the study by the investigator.

Normal Demand Pattern: From the weekly demand pattern the demand with mean 1000 and standard deviation 300 is assumed to be normally distributed and is taken as low demand pattern for the study

High Demand Pattern: For the high demand pattern study, mean with1500 and standard deviation 400 is assumed to be normally distributed from the weekly demand pattern for the study

Parameters Used for the Study

The following parameters which are used in the analysis

'c' = Wholesale price/unit
'v' = Production cost/unit
's' = Salvage value/unit
'S_M' = Salvage value for the manufacturer
'C_o' = cost of overstocking by one unit
'C_u' = cost of under stocking by one unit
'b' = buyback price/unit
'p' = Retail price/unit
'f' = fraction of revenue shared by retailer with supplier
'S_R' = Salvage value of leftover units by retailer/unit
'Q' = upper limit of demand in units
'q' = lower limit of demand in units
'D' = Demand in units
'ERP' = Expected Retailer Profit
'ESP' = Expected Supplier Profit
'ESCP' = Supply Chain Profit
'μ' = Mean
'σ' = Standard Deviation
'***csl***' = Cycle Service Level

Cycle service level is the probability that the demand during the season will be at or below order quantity '***O***'

At the optimal cycle service level '***csl***', the marginal contribution of purchasing an additional unit is zero. If the order quantity is raised from '***O***' to 'O+1', the additional unit sells if demand is larger than '***O***'. This occurs with probability 1-csl and results in a contribution of p-c

Analysis of Selected Three Contracts

The analysis of the selected three contracts is explained below:

Analysis of Buyback Contract

A buyback or return clause in a contract allows a retailer to return unsold inventory up to a specified amount, at an agreed upon price. The analysis of buyback contract starts with the calculation of expected retailer and supplier profit under low demand pattern, keeping the fixed wholesale price per unit, '***c***' and varying the buyback price, '***b***' for a given retailer price.

The corresponding cycle service level '***csl***' is calculated using the formula as quoted by (Sunil Chopra, 2010)

Cycle service level = (p-c)/(p-s) = C_u/C_u+C_o ----------------(i)
Optimal order quantity = NORMINV (CSL, μ, δ) --------- (ii)
Expected profit for retailer is given by
ERP = (p-s)μNORMDIST((O-μ)/δ,0,1,1)–(p-s)δNORMDIST ((O-μ)/δ,0,1,0) -O(c-s)NORMDIST ((O,μ,δ,1) + O(p-c) [1-NORMDIST((O,μ,δ,1) ------- (iii)

Expected Overstock = (O-μ) NORMDIST ((O-μ)/δ, 0,1,1) + δNORMDIST ((O-μ)/δ, 0,1,0) --------(iv)
Expected profit for supplier = O(c-v)-(b-Sm)*exp. Overstock at retailer ------- (v)
Exp. Supply chain profit = Exp. retailer profit + Exp. Supplier Profit ------------ (vi)

The analysis of low, normal and high demand pattern under buyback contract for wholesale price per unit, ***c*** = 3,4,5 and 6 by varying the buyback prices for per cent change in expected retailer profit, expected supplier profit and order quantity are discussed in Tables I, II and III respectively under results and discussion.

Analysis of Revenue Sharing Contract

The Revenue sharing contract allows the manufacturer to charge the retailer a low wholesale price '***c'*** and shares a fraction '***f'*** of the retailer's revenue. Even if no returns are allowed, the lower wholesale price decreases the cost to the retailer in case of an overstock. The retailer thus increases the level of product availability resulting in higher profits for both the manufacturer and the retailer.

The manufacturer has a production cost v and the retailer charges a retail price p and can salvage any leftover units for ***S_R***. The optimal order quantity '***O'*** ordered by the retailer is evaluated using equation (vii) and equation (viii) and the cycle service level is calculated using equation (ix) as quoted by (Sunil Chopra, 2010).

Cost of under stocking = Cu = (1-f)*p – c) ----------------- (vii)
Cost of overstocking = Co = c - S_R ------------------------ (viii)
Cycle service level = C_u/C_u+C_o=[(1-f)(p-c)]/[(1-f)(p-S_R)] –(ix)
Optimal order quantity = NORMINV (CSL,μ,δ) ---------(x)

The manufacturer obtains the wholesale price c for each unit purchased by the retailer and a share of the revenue for each unit sold by the retailer. The expected overstock at the retailer is obtained by using equation (xi)

Expected overstock at retailer = $(O-\mu)\mathrm{NORMDIST}((O-\mu)/\delta,0,1,1)+\delta\,\mathrm{NORMDIST}((O-\mu)/\delta,0,1,0)$ ----------- (xi)

Expected retailer profit = $(1-f)*p*(O-$exp. overstock at retailer$) + (S_R*$exp. overstock at retailer $- c*O)$ ------- (xii)

Exp. supply chain profit = Exp. supplier profit + Exp. retailer profit) --------- (xiii)

The variation in order quantity is also calculated. The analysis continues by changing the different values of wholesale price per unit, '***c***' while keeping the fixed retailer price per unit, '***p***' with the different revenue sharing fraction under low demand pattern. The percent change of expected retailer profit, supplier profit and order quantity are calculated.

The analysis of low, normal and high demand pattern under revenue sharing contract for wholesale price per unit, ***c*** = 3,4,5 and 6 by varying the buyback prices for per cent change in expected retailer profit, expected supplier profit and order quantity are discussed in Tables IV, V and VI respectively under results and discussion.

Analysis of Quantity Flexibility Contract

Under Quantity Flexibility contracts, the manufacturer allows the retailer to change the quantity ordered after observing the demand. If a retailer orders '***O***' units, the manufacturer commits to providing $Q = (1+\alpha)\,O$ units, whereas the retailer is committed to buying at least $q= (1-\beta)\,O$ units. Both α and β are between 0 and 1. The retailer can purchase up to **Q** units, depending on the demand it observes. These contracts are similar to buyback contracts in that the manufacturer now bears some of the risk of having excess inventory. Because no returns are required, these contracts can be more effective than buyback contracts when the cost of returns is high. Quantity flexibility contracts increase the average amount the retailer purchases and may increase total supply chain profits.

The manufacturer incurs a production cost of $\boldsymbol{v}$ per unit and charges a wholesale price of c from the retailer. The retailer salvages any leftover units for $\boldsymbol{S_R}$. The manufacturer salvages any leftover units for $\boldsymbol{S_M}$. If retailer demand is normally distributed with a mean of $\boldsymbol{\mu}$ and standard deviation of $\boldsymbol{\sigma}$ the various equations used to evaluate the contract given by the following equations as quoted by Sunil Chopra (2010).

Supplier is committed to produce $Q = (1+\alpha)*O$ units – (xiv)

Retailer is committed to buy at least $q = (1-\beta)*Q$ units --- (xv)

Expected quantity purchased by retailer is given by
$Q_R = q\,F(q)+Q(1-F(Q))+\mu Fs[(Q-\mu)/\delta)-Fs((q-\mu)/\delta)-\delta[fs((Q-\mu)/\delta) - fs((q-\mu)/\delta)]$ ---------- (xvi)
Expected quantity sold by the retailer is given by
$D_R = Q\,[\,1-F(Q)] + \mu Fs((Q-\mu)/\delta) - \delta fs((q-\mu)/\delta$ -----(xvii)
Expected overstock at manufacturer = $Q_R - D_R$ --------- (xiii)
Exp. retailer profit = $D_R *p + (Q_R - D_R)\,S_R - Q_R * c$ -- (xix)
Exp. manufacturer profit = $Q_R * c + (Q - Q_R)*S_M - Q*v$ - (xx)

The variation in order quantity is also calculated. The analysis continues by changing the different values of wholesale price per unit, '***c***' while keeping the fixed retailer price per unit, '***p***' with the different flexibility constant under low demand pattern. The percent change of expected retailer profit, supplier profit and order quantity are calculated.

The analysis of low, normal and high demand pattern under quantity flexibility contract for wholesale price per unit, ***c*** = 3,4,5 and 6 by varying the buyback prices for per cent change in expected retailer profit, expected supplier profit and order quantity are discussed in Tables VII, VIII and IX respectively under results and discussion.

Analysis Within Contracts

The analysis within the three selected buyback, revenue sharing and quantity flexibility contracts is made by comparing within low, normal and high demand patterns for per cent change in expected retailer profit (% ERP), per cent change in expected supplier profit (% ESP) and per cent change in order quantity (% OQ) are analyzed for various wholesale price per unit, ***c*** = 3, 4, 5 and 6 is shown in Table X under result and discussions.

Analysis Between Contracts

The analysis is carried out between buyback, revenue sharing and quantity flexibility contracts for per cent change in expected retailer profit (% ERP), per cent change in expected supplier profit (% ESP) and per cent change in order quantity (% OQ) by varying wholesale prices per unit, ***c*** = 3, 4, 5 and 6 is shown in Table XI under result and discussions.

IV. RESULTS AND DISCUSSIONS

Analysis of Buyback Contract

The analysis of the buyback contract is made between low, normal and high demand patterns for different values of wholesale price per unit, 'c'.

TABLE I

LOW DEMAND PATTERN IN BUYBACK CONTRACT

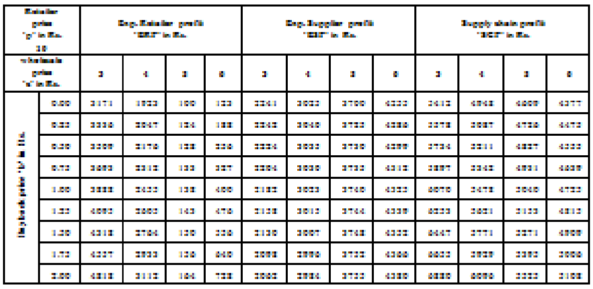
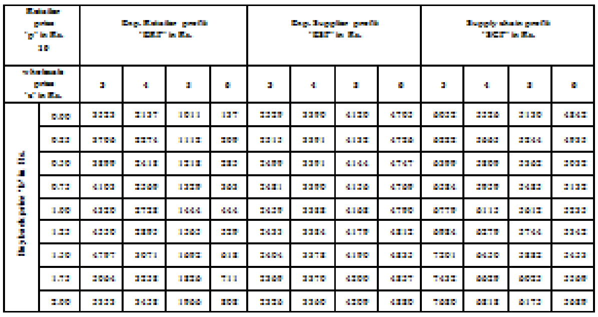


TABLE II

NORMAL DEMAND PATTERN IN BUYBACK CONTRACT

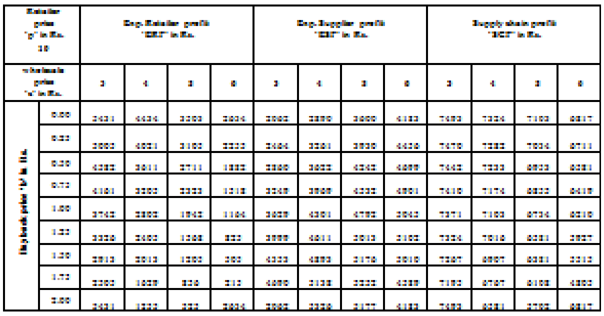


The result for low demand pattern in a buyback contract from Table I when wholesale price/unit, c = 3 and 4, reveal as the buyback price increases, the expected retailer profit and supply chain profit increases whereas the expected supplier profit decreases and when wholesale price/unit, c = 5 and 6 it shows that all the expected retailer profit, expected supplier profit and supply chain profit increases.

The result for normal demand pattern in a buyback contract from Table II when wholesale price/unit, c = 3 and 4, reveal as the buyback price increases, the expected retailer profit and supply chain profit increases whereas the expected supplier profit decreases and when wholesale price/unit, c = 5 and 6 it shows that all the expected retailer profit, expected supplier profit and supply chain profit increases.

TABLE III

HIGH DEMAND PATTERN IN BUYBACK CONTRACT



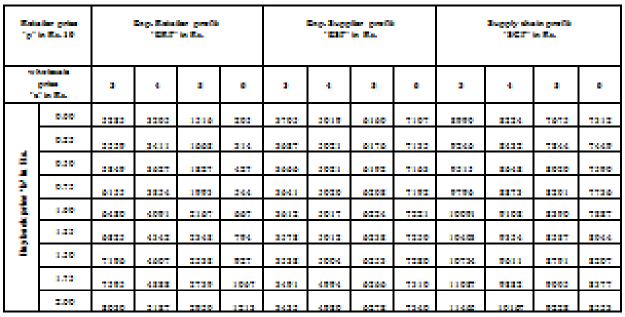
The result for high demand pattern in a buyback contract from Table III when wholesale price/unit, c = 3 and 4, reveal as the buyback price increases, the expected retailer profit and supply chain profit increases whereas the expected supplier profit decreases and when wholesale price/unit, c = 5 and 6 it shows that all the expected retailer profit, expected supplier profit and supply chain profit increases.

Analysis of Revenue Sharing Contract

The analysis of the Revenue Sharing Contract is made between low, normal and high demand patterns for different values of wholesale price per unit, ‘c’.

TABLE IV

LOW DEMAND PATTERN IN REVENUE SHARING CONTRACT



The result for low demand pattern in a revenue sharing contract from Table IV when wholesale price/unit, c = 3, 4, 5 and 6 reveal as the revenue sharing fraction increases, expected supplier profit increases whereas expected retailer profit and supply chain profit decreases.

The result for normal demand pattern in a revenue sharing contract from Table V when wholesale price/unit, c = 3, 4, 5 and 6 reveal as the revenue sharing fraction increases, expected supplier profit increases whereas expected retailer profit and supply chain profit decreases.

TABLE V
NORMAL DEMAND PATTERN IN REVENUE SHARING CONTRACT

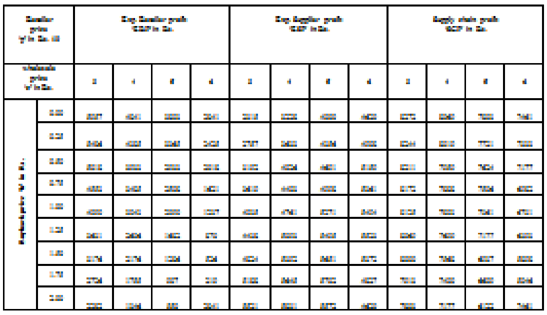
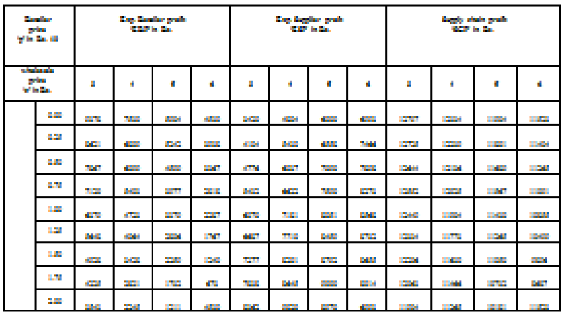


TABLE VI
HIGH DEMAND PATTERN IN REVENUE SHARING CONTRACT

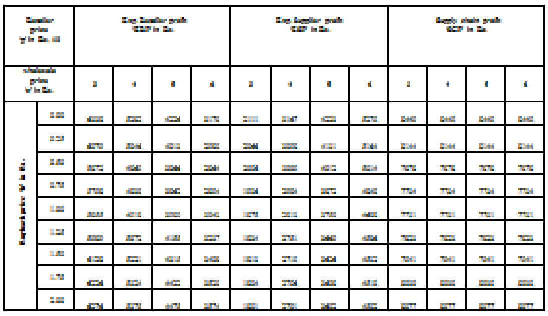


The result for high demand pattern in a revenue sharing contract from Table VI when wholesale price/unit, c = 3, 4, 5 and 6 reveal as the revenue sharing fraction increases, expected supplier profit increases whereas expected retailer profit and supply chain profit decreases.

Analysis of Quantity Flexibility Contract

The analysis of the Quantity Flexibility Contract is made between low, normal and high demand patterns for different values of wholesale price per unit, ‘c’.

TABLE VII
LOW DEMAND PATTERN IN QUANTITY FLEXIBILITY CONTRACT



The result for low demand pattern in a quantity flexibility contract from Table VII when wholesale price/unit, c = 3, 4, 5 and 6 reveal as the flexibility constant increases, expected retailer profit slightly increases and supply chain profit decreases at lower flexibility constant values and tend to increase at the higher values of flexibility constant and the expected supplier profit decreases.

The result for normal demand pattern in a quantity flexibility contract from Table VIII when wholesale price/unit, c = 3 and 4, reveal as the flexibility constant increases, the expected retailer profit increases and supply chain profit decreases at lower flexibility constant values and tend to increase at the higher values of flexibility constant and the expected supplier profit decreases whereas when wholesale price/unit, c = 5 and 6 it shows that when the flexibility constant increases the expected retailer profit and supply chain profit increases and there is no change in expected supplier profit.

The result for high demand pattern in a quantity flexibility contract from Table IX when wholesale price/unit, c = 3, 4, 5 and 6 reveal as the flexibility constant increases, both the expected retailer profit and supply chain profit increases earlier and tend to decreases later and the expected supplier profit increases.

TABLE VIII
NORMAL DEMAND PATTERN IN QUANTITY FLEXIBILITY CONTRACT

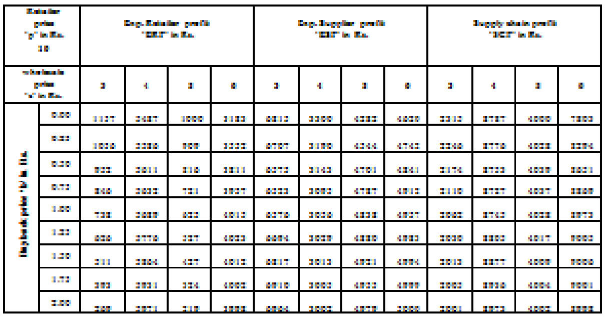


TABLE IX
HIGH DEMAND PATTERN IN QUANTITY FLEXIBILITY CONTRACT

[illegible]		Exp. Retailer profit 'ERP' in Rs.				Exp. Supplier profit 'ESP' in Rs.				Supply chain profit 'SCP' in Rs.			
wholesale price 'c' in Rs.		3	4	5	6	3	4	5	6	3	4	5	6
[illegible]	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Analysis Within Contracts

The analysis within the three selected buyback, revenue sharing and quantity flexibility contracts is made by comparing within low, normal and high demand patterns for per cent change in expected retailer profit (% ERP), per cent change in expected supplier profit (% ESP) and per cent change in order quantity (% OQ) for different wholesale prices 'c' = 3, 4, 5 and 6 and the results are discussed in Table X as shown below:

TABLE X
ANALYSIS WITHIN EACH CONTRACT FOR %ERP, %ESP AND % OQ

Demand pattern	Whole sale price, 'c' in Rs.	BUYBACK CONTRACT			REVENUE SHARING CONTRACT			QUANTITY FLEXIBILITY CONTRACT		
		% ERP	% ESP	% OQ	% ERP	% ESP	% OQ	% ERP	% ESP	% OQ
Low	3	51.86	7.88	15	61.30	142.51	12.71	0.66	14.70	109.21
	4	61.84	1.94	11	71.71	84.90	17.75	1.77	14.70	109.21
	5	84.58	1.50	8	85.00	49.79	26.87	5.66	14.70	109.21
	6	481.86	2.86	6	91.62	8.70	95.04	12.74	14.70	109.21
Normal	3	51.86	8.01	16	61.66	138.54	13.58	2.18	13.58	109.21
	4	61.84	0.87	12	72.21	80.65	18.07	6.63	9.04	101.14
	5	84.58	2.16	10	85.53	38.90	28.02	16.38	0.04	87.21
	6	481.86	2.72	6	4.46	4.46	98.08	25.60	6.29	84.61
High	3	51.86	7.29	15	62.22	144.53	12.27	2.06	28.48	109.21
	4	61.84	0.79	11	70.18	87.77	17.08	6.18	28.48	109.21
	5	84.58	1.89	8	78.48	48.48	25.60	17.23	28.48	109.21
	6	481.86	3.36	7	85.14	14.58	99.54	32.06	28.48	109.21

KEY: %ERP – Per cent for Expected Retailer Profit, %ESP – Per cent for Expected Supplier
Profit, % OQ – per cent for Order Quantity

From Table X, it reveals that the per cent increase in expected retailer profit is more when wholesale price c = 6 during low, normal and high demand pattern when compared within buyback contract. It is also noted that the percent increase in expected retailer profit increases as the wholesale price 'c' increases. It reveals that the per cent increase in expected supplier profit is more when wholesale price c = 3 at low, normal and high demand pattern when compared within buyback contract. It reveals that the per cent increase in order quantity is more when wholesale price c = 3 at low, normal and high demand pattern and decreases as the wholesale price 'c' increases when compared within buyback contract.

From Table X, it reveals that the per cent increase in retailer profit is more when wholesale price c = 6 at low and high demand pattern when compared within revenue sharing contract. It reveals that the per cent increase in expected supplier profit is more (144.53%) when wholesale price c = 3 at high demand pattern and less when wholesale price c = 6 at normal demand pattern when compared within revenue sharing contract. It is also revealed that the % change in expected supplier profit decreases as the wholesale price c increases. It shows that the percent change in order quantity for the revenue sharing contract increases as the wholesale price increases under all the three demand patterns when c = 6, when compared within revenue sharing contract.

From the Table X, it revealed that the per cent increase in expected retailer profit in a quantity flexibility contract increases as the wholesale price c increases under three demand patterns when compared within quantity flexibility contract. It revealed that the per cent increase in expected supplier profit in a quantity flexibility contract remains constant at low and high demand patterns whereas it decreases as the wholesale price c increases under normal demand pattern when compared within quantity flexibility contract. It revealed that the per cent increase in order quantity in a quantity flexibility contract remains constant at low and high demand patterns whereas it decreases as the wholesale price c increases under normal demand pattern when compared within quantity flexibility contract.

Analysis Between Contracts

The analysis is carried out between Buyback, Revenue Sharing and Quantity Flexibility contracts for low, normal and high demand patterns for per cent change in expected retailer profit (% ERP), per cent change in expected supplier profit (% ESP) and per cent change in order quantity (% OQ) for various wholesale prices c = 3, 4, 5 and 6 is discussed below in Table XI

TABLE XI
ANALYSIS BETWEEN CONTRACTS FOR %ERP, %ESP AND % OQ

Demand pattern	Whole sale price, 'c' in Rs.	% ERP			% ESP			% OQ		
		BBC	RSC	QFC	BBC	RSC	QFC	BBC	RSC	QFC
Low	3	51.95	61.30	0.98	7.99	142.51	14.70	15	12.71	109.21
	4	61.84	71.71	1.77	1.34	84.30	14.70	11	17.75	109.21
	5	94.59	85.00	5.88	1.50	43.79	14.70	9	26.87	109.21
	6	491.96	91.82	12.74	2.96	9.70	14.70	8	35.04	109.21
Normal	3	51.95	61.69	2.19	8.01	138.54	13.53	16	13.59	109.21
	4	61.84	72.21	8.83	0.87	80.65	9.04	12	19.07	101.14
	5	94.59	85.53	16.28	2.16	39.30	0.04	10	29.02	97.21
	6	491.96	4.48	25.60	3.72	4.48	8.23	8	38.08	94.81
High	3	51.95	62.22	2.08	7.29	144.53	29.49	15	12.27	109.21
	4	61.84	70.19	8.19	0.79	87.77	29.49	11	17.09	109.21
	5	94.59	79.49	17.23	1.93	49.49	29.49	8	25.80	109.21
	6	491.96	85.14	32.00	3.28	14.59	32.00	7	33.54	109.21

KEY: BBC – Buyback Contract, RSC – Revenue Sharing Contract, QFC - Quantity
Flexibility Contract, %ERP – Per cent for Expected Retailer Profit, %ESP – Per
cent for Expected Supplier Profit, % OQ – per cent for Order Quantity

From the Table XI, it revealed that the per cent increase in retailer profit of a buyback contract is more when compared to revenue sharing and quantity flexibility contract. It is also noted that the per cent increase in retailer profit when compared among three contracts is less for quantity flexibility contract.

From the Table XI, it revealed that the per cent increase in supplier profit of a revenue sharing contract is more when compared to buyback and quantity flexibility contract. It is also noted that the per cent increase in supplier profit when compared among three contracts is less for buyback contract.

From the Table XI, it revealed that the per cent increase in order quantity of a quantity flexibility contract is more when compared to revenue sharing and quantity flexibility contract. It is also noted that the per cent increase in order quantity when compared among three contracts is less for buyback contract.

V. CONCLUSION

The impact of three types of supply chain contracts on manufacturer, retailer and supply chain profit are analyzed. From the results obtained it is concluded that the buyback contract increases the profits of the supply chain and allows the manufacturer increases its own profits and it also encourages the retailer to increase the level of product availability. It is also concluded that in revenue sharing contract the profit of the supply chain is more compared to the profit obtained from buy back contract. It is also concluded that the quantity flexibility contract is very effective if a supplier is selling to multiple retailers with independent demand.

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